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Does an Exercise Intervention Improving Aerobic Capacity Among Construction Workers Also Improve Musculoskeletal Pain, Work Ability, Productivity, Perceived Physical Exertion, and Sick Leave?

A Randomized Controlled Trial

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Objective: To investigate whether an exercise intervention shown to increase aerobic capacity, would also lead to less musculoskeletal pain; improved work ability, productivity, and perceived physical exertion; and less sick leave. **Methods:** Sixty-seven construction workers were randomized into an exercise group training 3×20 minutes per week and a control group. Questionnaires and text messages were completed before and after the 12-week intervention. **Results:** No significant changes were found in musculoskeletal pain, work ability, productivity, perceived physical exertion, and sick leave with the intervention. Questionnaires and text messages provided similar results of pain and work ability. **Conclusions:** Although the intervention improved aerobic capacity, it was not successful in improving musculoskeletal pain and other work-related factors. A detectable improvement presumably requires a more multifaceted intervention, larger sample size, or longer follow-up. Text messages may be a convenient data-collection method in future studies.

Construction workers are exposed to physically demanding work, such as frequent lifting, awkward postures, static work postures, handling of heavy objects, and unexpected peak loads.¹ Such work-related demands require a high musculoskeletal and aerobic physical capacity to remain healthy and active in the labor market until retirement age.²⁻⁴ However, construction workers were observed to have lower capacity than a representative sample of workforce in Denmark.⁵ Accordingly, construction workers were shown to be at higher risk of occupational disability when musculoskeletal disorders and cardiovascular diseases were the main causes.¹⁻⁶ Among construction workers, musculoskeletal disorders and cardiovascular diseases are major causes of sick leave, permanent disability, and early retirement³, and low work ability was shown to predict disability.⁷ However, high physical capacity was shown to be associated with good work ability and thereby decreasing the risk of sick leave.⁴ Therefore, physical exercise activities that focus on enhancing physical capacity may be effective for improving work ability and reducing sick leave among construction workers.

Loss in productivity related to health problems at work has been defined as sickness presenteeism.⁸ Studies have shown a strong association between sick leave and sickness presenteeism.^{8,9} Good

cardiovascular fitness and physical activity at moderate and vigorous levels are associated with high performance at work, whereas obesity and sedentary lifestyle are related to sickness presenteeism.¹⁰ Furthermore, individuals with upper back/neck pain were shown to have an elevated sickness presenteeism.⁹

During the past 15 years, several articles have been published about health issues among construction workers, but there are few studies about physical activity intervention.¹¹⁻¹³ Recently, we conducted an intervention study that improved aerobic capacity⁵ and showed it is feasible to offer a tailored exercise intervention in a construction workplace setting. The intervention offered both aerobic training and muscle strength training, depending on the individually measured capacity. Within other job groups, several studies^{14,15} have documented a decrease in pain with muscle strength training. However, aerobic endurance training has also been shown to decrease muscle pain,¹⁶⁻¹⁸ both as an acute decrease¹⁴ and a decrease in pain response during a repetitive work task.¹⁹ We investigated secondary outcome variables: musculoskeletal pain, work ability, productivity, perceived physical exertion, and sick leave in response to the intervention previously reported to increase aerobic capacity.⁵ To optimize the validity of the data and due to challenges in data collection among construction workers, we also examined the use of text messaging for data collection compared with questionnaire. Text messages were chosen because construction workers generally are equipped with cell phones and therefore may find it a convenient method to respond to questions.

The objective of this article was twofold: (1) to investigate whether an exercise intervention, successfully increasing aerobic capacity, could affect musculoskeletal pain, work ability, productivity, perceived physical exertion, and sick leave among construction workers and (2) to compare two methods of data collection, that is, questionnaire and text messages, regarding musculoskeletal pain and work ability.

METHODS

Study Design

The study was a randomized, controlled intervention study; details regarding the design as well as recruitment and inclusion have previously been described.^{5,20} The participants were construction workers who completed a health check before and after the intervention. After the first health check, participants were randomized into exercise or control group. The randomization was performed blinded and was balanced regarding age and workplace.

The exercise intervention lasted 1 hour a week (3×20 minutes) for 12 weeks and consisted of aerobic capacity training and muscle strength training and is described in detail in the following text.

Written informed consent was obtained from all participants before enrollment in the study. The study protocol was

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The authors declare no conflict of interest.

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approved by the Region of Ethics committee of Southern Denmark (no. 20090068) and registered in www.clinicaltrials.gov (no. NCT1007669).

Subjects

Nine construction companies in Denmark were contacted and invited to participate. Three companies responded positively. The total number of eligible participants was 154 construction workers of whom 102 subjects completed a screening survey. The inclusion criteria were (1) more than 20 working hours per week and (2) having physically demanding tasks with high peak loads.

All participants were individually notified about the results of their health check. The health check consisted of several physical measurements and completion of a questionnaire. The questionnaire included, for example, questions about pain in neck–shoulder, back, and hip–knee region; work ability; productivity at work; perceived physical exertion at work; and sick leave. In addition, musculoskeletal pain and work ability were weekly reported by text messages during the intervention period.

Intervention

The exercise intervention was performed during working hours on or nearby the workplace and implemented in collaboration with the employer. The 12-week program was structured as 3 × 20 minutes per week and was supervised regularly by skilled instructors. For details, see Gram et al.⁵ In short, the exercise program was designed to target the two primary variables in this study: maximal oxygen uptake ($\dot{V}O_{2max}$) and muscle strength. The exercise program was individually tailored and was based on estimated $\dot{V}O_{2max}$ ²¹ and tests of maximal muscle strength in three body regions: neck–shoulder (2 tests), abdomen–back (2 tests), and hip–knee (1 test).²² The individual test results from the first health check were compared with reference values from the Danish working population.²² If the test value was less than 80% of reference value, the corresponding training element was included in the individual training instruction. Participants with all their test values being greater than 80% of reference value trained the capacity that was lowest on the job-group level, that is, aerobic capacity. Each participant received his or her own individual exercise protocol in a training diary that had to be filled in at each training session. All training sessions included 10-minute dynamic exercises for warm-up and aerobic capacity (increasing from ~50% to 70% estimated maximal workload) followed by 10 minutes with the individually tailored exercises. The intensity of the muscle strength training was approximately 60% of one repetition maximum, and the intensity of the aerobic capacity training was at least 70% of $\dot{V}O_{2max}$. Two times during the 12-week training period, the intensity of both the aerobic training and muscle strength training was measured and adjusted if needed.

The control group was not offered exercise training, but was given a 1-hour lecture on general health promotion.

Outcome Measures

All measurements at baseline were performed before randomization and repeated after the intervention. Outcome variables were musculoskeletal pain in neck–shoulder, lower back, and hip–knee; work ability; productivity; perceived exertion; and sick leave. All the questions were measured with the frame for interventions for preserved work ability, long term effect (FINALE) questionnaire.²⁰ In addition, pain intensity and work ability were reported by text messages.

Pain Intensity

For each body region, the 7-day prevalence of musculoskeletal symptoms was assessed by the question: On a scale ranging from 0

to 10, please specify the degree of pain the last 7 days (0 = no pain and 10 = pain as bad as it could be).²³

In the weekly text messages, three questions about pain were asked and scored on a scale ranging from 0 to 9 (to allow single-digit answers). One for each body region (neck–shoulder, lower back, and hip–knee): On a scale ranging from 0 to 9, how much pain did you experience in the [body region] during the last week? (0 = no pain, 9 = worst pain imaginable).

Work Ability

This was assessed from two items of the Work Ability Index.²⁴ The questions were (1) How would you rate your current work ability on a scale ranging from 0 to 10 (0 = completely unable to work, 10 = work ability at its best) and (2) If you think about your health, do you think that you will still be able to perform your job in 2 years' time (“inconceivable,” “not sure,” “surely”).

In the text messages, the question was: On a scale ranging from 0 to 9, how would you rate your work ability during the last week? (0 = completely unable to work, 9 = work ability at its best). A rating of 7 was chosen as the cutoff point for low work ability.

Productivity

To measure productivity at work, one question was used: How do you assess your productivity in your work the last month (range, 0 to 10; 0 = the worst anyone could perform, 10 = the absolute best as an employee of my job has to offer).

Perceived Physical Exertion

Perceived exertion as an expression of workload was measured using the Borg scale (range, 6 to 20).²⁵ The question in the FINALE questionnaire was: How physically hard do you perceive your current job?

Sick Leave

Self-reported sick leave was obtained by the question: How many days of sick leave have you had in the previous 3 months?

Statistical Analyses

The statistical analyses were based on an intention-to-treat (ITT) principle. Missing values at either baseline or follow-up were extrapolated by data carried forward or backward. Missing values in both baseline and after measurement were replaced by means of all existing values within the particular variable. Data of sick leave and productivity were analyzed not including participants on long-term sickness absence (>20 days) ($n = 3$).

Because the pain scale ranged from 0 to 10 in the questionnaire and from 0 to 9 for text messages, the text message–based information was scaled by 10/9 before further analysis. The pain questions via text messages were phrased as “neck–shoulder” and “hip–knee,” and therefore the answers from the questionnaire concerning these questions were pooled when analyzing the agreement. The construction of these pooled variables was done by using the highest value answered concerning questions about neck and shoulder. The same procedure was used concerning hip and knee.

Differences between groups in pain intensity, work ability, productivity, physical exertion, and sick leave were tested using analyses of covariance (ANCOVA). The second question concerning work ability “... will still be able to perform your job in 2 years' time” was tested using chi-squared test.

Text message–based variables were analyzed with mixed linear model and ANCOVA. To evaluate the differences in pain intensity variables of the intervention group and the control group, ANCOVA was used before (weeks 1 and 2) and after (weeks 11 and 12) intervention.

Post hoc analyses for within-group effects were performed by paired t test. Agreement between questionnaire and weekly text

message information was analyzed with the Bland-Altman technique for both pre- and post-time points as discussed earlier and stratified by intervention/control group. The statistical computer program used was STATA SE10 (StataCorp LP, College Station, TX).

RESULTS

Study Population

Sixty-seven male construction workers participated in the study. Detailed information about eligibility criteria, setting, location, intervention, definition of outcomes, and so forth is given in our previously published article about the primary outcome.⁵ In short, the study group is considered to be representative of Danish construction workers in general, as the companies included in the study provide a broad representation of the industry and were from different geographic locations in Denmark. Two participants ($n = 1$ from the intervention group, $n = 1$ from the control group) did not complete all tests in the health check due to sickness absence but did answer the questionnaire and replied on text messages. Two participants did not fill out the baseline questionnaire but completed the follow-up measurement and replied to the text messages. Concerning text messages, the response rate was 85%, that is, 10 participants ($n = 6$ from the intervention group, $n = 4$ from the control group) or 15% did not reply to any text messages. These 10 participants had a mean age of 55 years; two participants dropped out and three could not be reached due to a foreign telephone number. The flowchart and the allocations to the individually tailored training were presented in a previously published article from the study.⁵

Baseline

Table 1 presents characteristics and outcome measures of the study population. The mean age was 43.7 ± 10.5 years, mean body mass index was 28.3 ± 4.7 kg/m². At baseline, there were no statistically significant differences between intervention and control group. Sick leave was analyzed without three participants (from the control group), as they were on long-term sick leave ($n = 2$ herniated disc/sick leave for the whole period, $n = 1$ damage on ankle joint ligament/sick leave for the first month of the period).

Twenty-seven percent of the participants reported a rating of 7 or lower on the work ability question scaled from 0 to 10 (31% in the exercise group and 22% in the control group).

Low back was the most affected region in terms of pain intensity according to the questionnaire, whereas neck/shoulder combined was most affected according to the text messages (Table 2). Results from weekly text messages, measured over the 12-week intervention period, are shown in Fig. 1. Concerning text measures over the 12-week intervention period, there was no significant difference in pain or work ability between the intervention and control groups through the intervention period.

Follow-up at 12 Weeks After Intervention and Changes

Musculoskeletal Pain

The absolute changes and differences in pain intensity from baseline to follow-up at 12 weeks are shown in Tables 2 and 3. There were no significant changes in pain intensity in shoulders, upper and lower back, or hip and knee, based on the questionnaire data and the text message replies.

Work Ability

The absolute changes and differences in work ability (scale, 0 to 10) from baseline to follow-up at 12 weeks are shown in Table 2 and Table 3. No significant changes were found in work ability in the ITT analyses. Subsequent post hoc analyses on a within-group effect did not reveal any significant changes or differences. The percentage of participants in the exercise group that reported moderate work ability rating of 7 or lower on the work ability scale decreased from 31.4% to 23% after the 12-week intervention, but not significantly. The choice of 7 as a cutoff point for this article was based on the results in a study about the Danish working population.²⁶ The study showed that only approximately 10% of the general Danish working population rated themselves at 7 or lower on the work ability scale. The question as to whether the participants still consider themselves to be able to perform the job in 2 years' time was estimated as frequencies and did not change significantly from baseline to follow-up (Table 3).

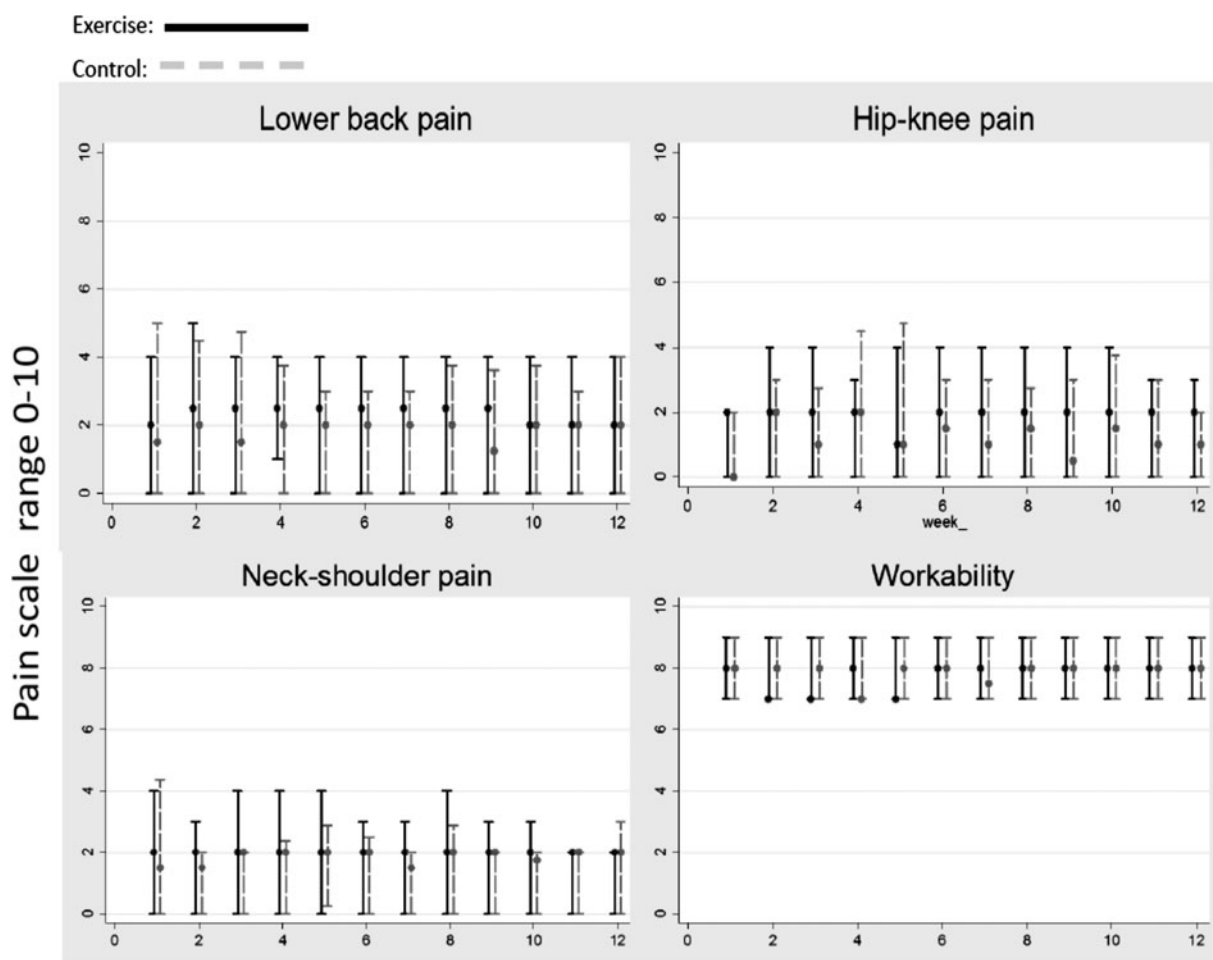
TABLE 1. Baseline Characteristics and Outcome Measures of the Study Population (Intention-to-Treat), Based on Questionnaire Information

Characteristics	Exercise Group ($n = 35$), Mean \pm SD	Control Group ($n = 32$), Mean \pm SD	Total ($n = 67$), Mean \pm SD (Range)
Age, yr	44 \pm 11.1	43 \pm 10.0	43.7 \pm 10.5 (21.9–63.4)
Body mass index	28.8 \pm 4.1	27.9 \pm 5.2	28.3 \pm 4.7 (18.9–44.6)
Work ability (scale, 0–10)	7.8 \pm 2.0	8.1 \pm 1.9	7.9 \pm 2.0 (1–10)
Still able to perform the job in 2 years' time ("inconceivable," "not sure," "surely"), %	3/14/83	3/9/88	3/12/85
Perceived exertion at work (scale, 6–20)	13.4 \pm 2.9	14.0 \pm 2.4	13.7 \pm 2.7 (6–20)
Self-rated productivity (scale, 0–10) (total $n = 64$)	8.2 \pm 1.5 ($n = 35$)	8.8 \pm 1.3 ($n = 29$)	8.5 \pm 1.5 (5–10)
Sick leave, d			
Last 3 months (total $n = 64$)	0.8 \pm 1.4 (35)	2.0 \pm 3.9 ($n = 29$)	1.4 \pm 2.9 (0–15)
Pain intensity last 7 days (scale, 0–10)			
Neck	1.3 \pm 2.1	1.4 \pm 1.7	1.3 \pm 1.9 (0–7)
Shoulder right	1.4 \pm 2.3	1.1 \pm 1.7	1.3 \pm 2.0 (0–8)
Shoulder left	1.0 \pm 2.3	0.8 \pm 1.5	0.9 \pm 2.0 (0–10)
Shoulder dominant	1.7 \pm 2.7	1.1 \pm 1.7	1.4 \pm 2.3 (0–10)
Upper back	1.3 \pm 1.9	1.2 \pm 2.1	1.2 \pm 2.0 (0–8)
Low back	2.7 \pm 2.9	2.6 \pm 2.6	2.6 \pm 2.7 (0–10)
Hip	1.0 \pm 2.4	0.8 \pm 2.0	0.9 \pm 2.2 (0–10)
Knee	1.9 \pm 2.7	1.6 \pm 2.4	1.8 \pm 2.6 (0–10)

TABLE 2. Pre- and Postmeasures, Based on Text Messages and Questionnaire for Each Study Group, Based on Intention-to-Treat

	Exercise Group (SD) Pre (n = 35)	Control Group (SD) Pre (n = 32)	Exercise Group Post-Pre (SD) (n = 35)	Control Group Post-Pre (SD) (n = 32)	Difference Exercise vs Control (SE)	95% CI	P
Text Messages							
Neck-shoulder	2.5 ± 2.4	1.9 ± 1.8	-0.2 ± 1.9	0.2 ± 1.0	-0.3 ± 0.3	-0.4 to 0.9	0.45
Low back	2.4 ± 2.7	2.5 ± 2.7	-0.5 ± 1.7	-0.5 ± 1.7	-0.2 ± 0.4	-1.1 to 0.7	0.66
Hip-knee	2.3 ± 2.5	2.0 ± 2.5	-0.1 ± 1.9	-0.1 ± 2.2	0.1 ± 0.4	-0.8 to 1.0	0.77
Work ability	7.8 ± 2.4	8.4 ± 2.2	0.1 ± 3.1	-0.7 ± 1.7	0.5 ± 0.6	-0.6 to 1.7	0.35
Questionnaire (pooled data)							
Neck-shoulder dominant	2.1 ± 2.8	2.1 ± 1.9	-0.3 ± 1.9	-0.2 ± 1.6	-0.1 ± 0.4	-0.8 to 0.7	0.90
Low back	2.7 ± 2.9	2.6 ± 2.6	-0.2 ± 2.2	0.0 ± 2.3	-0.2 ± 0.5	-1.2 to 0.8	0.73
Hip-knee	2.1 ± 3.0	1.9 ± 2.5	-0.1 ± 2.7	-0.0 ± 2.1	-0.0 ± 0.5	-1.1 to 1.0	0.97
Work ability	7.8 ± 2.0	8.0 ± 1.9	0.4 ± 1.6	-0.1 ± 1.3	0.4 ± 0.3	-0.2 to 1.1	0.21

Values are mean ± SD. Means from text messages: Pre are means from weeks 1 and 2, and Post are means from weeks 11 and 12. Differences are estimated as the difference between means with 95% CI, based on the 1-factor analysis of covariance with the level at baseline applied as a covariate. Text message-based information was scaled by 10/9 and questionnaire data from neck and shoulder, respectively, and hip and knee, respectively, are pooled to be neck-shoulder and hip-knee. 95% CI, 95% confidence interval.

**FIGURE 1.** Progress in pain weeks and work ability in exercise and control groups throughout the intervention period, based on information from weekly text messages (50th medians, percentile 25, 50, 75). Exercise, *n* = 29; control, *n* = 28.

Self-rated Productivity

No significant change from baseline to follow-up at 12 weeks in self-rated productivity was observed (Table 3).

Perceived Physical Exertion at Work

There was no significant change from baseline to follow-up at 12 weeks in perceived physical exertion in the ITT analyses or in the post hoc analyses (Table 3).

Sick Leave

Sick leave during the past 3 months did not show any significant change in self-reported measures from baseline to follow-up at 12 weeks (Table 3).

Agreement Between Questionnaire and Text Messages

Regarding work ability, the participants reported an average of 7.9 ± 2.0 (scale, 0 to 10) in the questionnaire, whereas the reply with text messages was 8.1 ± 2.3 (adjusted to scale ranging from 0 to 10). The mean intensity of low back pain was 2.5 ± 2.6 in questionnaire and 2.8 ± 2.7 in text messages. The mean intensity of neck-shoulder pain using questionnaire was 2.1 ± 2.4 and in text messages 2.2 ± 2.1 , and intensity of hip-knee pain using questionnaire was 0.9 ± 2.2 and in text messages 2.1 ± 2.5 . Bland-Altman analyses (Fig. 2) showed at baseline a mean difference (95% limits of agreement) of low back pain of -0.33 (-5.5 to 4.8) and a Spearman $\rho = 0.5$, which indicates reasonable agreement on group level between the two methods, as there was no significant difference between the variables at baseline ($P < 0.30$) or after the intervention ($P < 0.74$). In neck-shoulder pain at baseline, the mean difference (95% limits of agreement) was -0.09 (-4.0 to 3.8) and Spearman $\rho = 0.5$. There was reasonable agreement both at baseline ($P < 0.72$) and at follow-up ($P < 0.21$). The mean difference at baseline in hip-knee pain was -0.1 (-4.4 to 4.1), Spearman $\rho = 0.7$. There were no significant differences between these variables at baseline ($P < 0.53$) or at follow-up ($P < 0.53$) and for work ability: mean -0.1 (-4.9

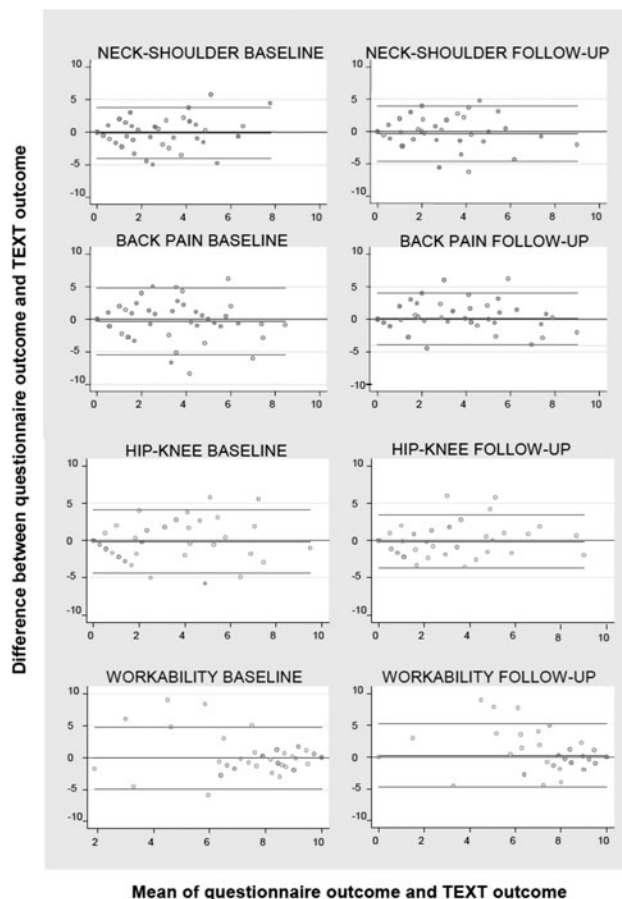


FIGURE 2. Level of agreement on pain variables and work ability between questionnaire and text message.

TABLE 3. Changes in Outcome Measures for Each Study Group From Before to After the 12-Week Intervention Period (Intention-to-Treat Analyses), Based on Questionnaire Information

Characteristics	Exercise Group Post-Pre (SD) (n = 35)	Control Group Post-Pre (SD) (n = 32)	Difference Exercise vs Control Groups (SE)	95% CI	P
Work ability (scale, 0–10)	0.4 ± 1.6	-0.1 ± 1.3	0.4 ± 0.3	-0.2 to 1.1	0.21
Still able to perform the job in 2 years' time ("inconceivable," "not sure," "surely"), %	$+3/0/-1$	$0/-3/+3$			
Perceived exertion at work (scale, 6–20)	0.1 ± 2.2	-0.3 ± 1.6	0.1 ± 0.3	-0.6 to 0.8	0.74
Self-rated productivity (scale, 1–10) (total n = 64)	-0.3 ± 2.1 (n = 34)	-0.1 ± 1.1 (n = 29)	-0.5 ± 0.5	-1.4 to 0.4	0.28
Sick leave, d					
Last 3 months (total n = 64)	0.7 ± 2.2 (n = 35)	0.1 ± 4.6 (n = 29)	-0.1 ± 0.8	-1.7 to 1.4	0.91
Pain intensity last 7 days (scale, 0–10)					
Neck	-0.2 ± 1.5	-0.2 ± 1.3	0.0 ± 0.3	-0.7 to 0.7	0.96
Shoulder right	0.0 ± 1.7	-0.4 ± 1.0	0.5 ± 0.3	-0.1 to 1.1	0.11
Shoulder left	-0.3 ± 2.4	0.1 ± 1.4	-0.3 ± 0.3	-1.0 to 0.4	0.37
Shoulder dominant	-0.3 ± 2.3	-0.4 ± 1.0	0.3 ± 0.3	-0.3 to 0.9	0.31
Upper back	-0.2 ± 1.6	-0.2 ± 1.9	0.0 ± 0.4	-0.8 to 0.8	0.92
Low back	-0.2 ± 2.2	0.0 ± 2.3	-0.2 ± 0.5	-1.2 to 0.8	0.73
Hip	-0.1 ± 3.0	0.2 ± 1.9	-0.2 ± 0.5	-1.2 to 0.8	0.74
Knee	-0.2 ± 2.7	-0.3 ± 1.8	0.2 ± 0.5	-0.8 to 1.2	0.70

Values are mean \pm SD and number (%). Changes in post-pre values are absolute and not adjusted. Differences are estimated as the difference between mean \pm SE with 95% CI, based on the 1-factor analysis of covariance with the level at baseline applied as a covariate. 95% CI, 95% confidence interval.

to 4.7), Spearman $\rho = 0.3$. Concerning the work ability question, at baseline there was no statistical difference between the two methods.

DISCUSSION

The main result of the study was that the worksite intervention previously shown to improve aerobic capacity among construction workers did not affect musculoskeletal pain, work ability, productivity, perceived physical exertion, and sick leave with an effect size detectable as significant in a study of this size.

Theoretically, it is conceivable that a significant improvement in aerobic capacity among construction workers with high physical work demands would lead to corresponding improvements in these factors. Potential explanations for the present findings will be discussed in the following text.

Work Ability, Sick Leave, and Productivity

Studies have documented a relationship between work ability and leisure time physical activity level,²⁷ and it has been stated that in general a fit worker has a better work ability.⁴ However, intervention studies with work ability as an outcome variable are scarce and for physical activity as intervention results are contradictory. One randomized controlled trial (RCT) with physical activity intervention among workers with high work demands showed a slight increase in work ability after the intervention.²⁸ In contrast, Jørgensen et al.²⁹ could not document any change in work ability after an intervention among female cleaners with an average work ability at baseline of only 7.5. An important factor for achieving an improvement in work ability is the baseline level, as a low level has a higher potential for improvement whereas a high level may result in a ceiling effect. Work ability was 7.9 in this study, that is, slightly higher than the average work ability for the female cleaners.²⁹

Several studies have demonstrated a relationship between aerobic capacity and sick leave as well as a positive effect on sick leave in physical exercise interventions.^{4,30,31} In addition, a randomized exercise intervention showed a significant increase in self-rated productivity, that is, increased quantity of work and work ability and decreased sickness leave.³² However, most studies are observational and can demonstrate only an association between sick leave and work ability and/or productivity.^{4,33,34}

The general lack of a significant effect of physical exercise intervention could be explained by the fact that improvement in work ability, sick leave, and productivity is influenced by several other factors. Tuomi et al.²⁷ showed that changes in work ability were strongly associated with leadership factors. Moreover, a systematic review on work-related and individual factors on work ability showed many important factors associated with work ability, that is, obesity, high mental work demands, lack of autonomy, poor physical work environment, and high physical workload.³⁵ Concerning the content of the intervention in this study, the emphasis was on improving physical capacity, and a change in aerobic capacity may have only a limited effect on work ability, sick leave, and productivity within a 3-month period. The limited effect in this study may indicate that physical exercise should be part of more multifaceted interventions to increase the effect, as also suggested in other studies.³⁵

Musculoskeletal Pain

Interestingly, in this study musculoskeletal pain was only modest on a group level compared with other studies.^{16,36} However, the different body regions showed a large range in individual pain. This variability and the general modest mean pain level may be reasons for the lack of improvement in musculoskeletal pain on a group level. In this study only one of the participants worked less than 37 hours per week. Thus, the study group represented workers working relatively many hours a week. This may indicate that those with musculoskeletal disorders or low muscle strength are not able to remain for longer periods of time in the workforce. Another rea-

son may be that the individualized mixture of aerobic and muscle strength training did not have the same positive effect on musculoskeletal pain as previously reported for each of these types of training separately.^{14,16}

Text Messages

On a group level, questionnaire and text messages showed reasonable agreements for the variables: low back pain, neck-shoulder pain, and hip-knee pain, both at baseline and after the intervention. Regarding work ability, there was good agreement between questionnaire and text messages at baseline, whereas after the intervention only a minor difference was found.

These results suggest that text messages may be a convenient method to obtain data from construction workers.

Strength and Weakness of the Study

The strength of this study is the RCT design, as this design is considered the most stringent approach for revealing cause-effect relationships between intervention and outcome.³⁷ However, the study bears no evidence on content and intensity for an intervention to make statistically significantly or clinically relevant changes in work ability, productivity, or sick leave. Thus, it is possible that not only the content of the intervention is crucial to achieve improvement in these variables but also the length of the intervention period and the weekly training sessions may be essential factors. The intensity of the $\dot{V}O_{2\max}$ training in this study corresponded to vigorous activity level, and an increase of the intensity would probably not be relevant, whereas the muscle strength training might benefit from higher intensity.

The sample size calculation in this study was based on minimal difference in physical capacity after the intervention. Presumably, a bigger sample size is needed to demonstrate significance of the small changes in musculoskeletal pain, work ability, productivity, and sick leave. Aforementioned studies showing positive results for reduction in musculoskeletal pain included 549 participants,³⁶ improvement in work ability included 260 participants,²⁸ increase in productivity included 177 participants,³² and decrease in sick leave included 85³⁰ and 177³² participants, respectively.

Even though associations between several work-related factors and work ability, sick leave, and productivity (for example, high mental workload and high physical workload) have been proven,^{10,32,35} the knowledge of an intervention-mediated change in these outcomes is insufficient, and the minimal significant difference (MIREDF) is not proven. Regarding the nonsignificant changes in work ability that we found, a possible type 2 error concerning this variable cannot be excluded in this study. A post hoc calculation was performed on the basis of the observed change in work ability ($\Delta = 0.4 \pm 0.3$). This analysis showed that it would require 298 participants to detect a statistically significant difference on a $P < 0.05$ in work ability.

CONCLUSION

This study did not show any significant improvements in musculoskeletal pain, work ability, productivity, perceived physical exertion, and sick leave after a 12-week exercise intervention. This is despite the fact that the intervention increased aerobic capacity and that the outcome variables used in this study have been shown to relate to physical capacity. To demonstrate significant changes (detectable differences) in variables, such as work ability, productivity, and sick leave, presumably a larger study population and/or longer periods of more multifaceted interventions are needed.

Replies to questionnaires and text messages matched well and indicate these two methods to be equally credible.

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